

What is claimed:

1 1. A monolithic single pass expanded beam mode active optical device for light
2 of a predetermined wavelength and a predetermined beam mode, comprising:

3 a substrate including a top substrate surface;

4 a waveguide layer coupled to the top surface of the substrate and including;

5 a semiconductor gain medium;

6 two expansion/contraction sections, each including a portion of the
7 semiconductor gain medium which is substantially transparent to light of the
8 predetermined wavelength wherein, at least a portion of the semiconductor
9 gain medium varies in thickness within said expansion/contraction portion of
10 the expansion/contraction section; and

11 an active section extending between the two expansion/contraction sections the
12 active section including an active portion of the semiconductor gain medium
13 which interacts with light of the predetermined wavelength, responsive to the
14 electric signal;

15 a semiconductor layer coupled to the waveguide layer;

16 a first electrode coupled to the substrate; and

17 a second electrode coupled to the semiconductor layer,

18 wherein the first and second electrodes are configured to receive the electric signal.

1 2. A monolithic expanded beam mode active optical device according to claim 1,
2 wherein the semiconductor gain medium is a bulk active semiconductor material.

1 3. A monolithic expanded beam mode active optical device according to claim 1,
2 wherein the semiconductor gain medium is a quantum well structure formed of a plurality of
3 sublayers of semiconductor material.

1 4. The monolithic expanded beam mode active optical device of claim 3,
2 wherein:

3 the waveguide layer further includes;

4 two input/output surfaces, each substantially perpendicular to the top substrate
5 surface;

6 a longitudinal axis extending between and substantially perpendicular to the two
7 input/output surfaces;

8 each of the plurality of sublayers extends;

9 substantially parallel to the top surface of the substrate in a direction perpendicular
10 to the longitudinal axis; and

11 from one of the two input/output surfaces to an other one of the two input/output
12 surfaces; and

13 each of the two expansion/contraction sections and the electroabsorption section
14 extend along the longitudinal axis adjacent to one of the two input/output surfaces.

1 5. A monolithic expanded beam mode electroabsorption modulator for
2 modulating light of a predetermined wavelength, including a quantum well structure
3 responsive to an electric signal having an on-voltage and an off-voltage, comprising:

4 a substrate including a top substrate surface;

5 a waveguide layer coupled to the top surface of the substrate and including;

6 two expansion/contraction sections, each including a plurality of sublayers,
7 which form the quantum well structure, wherein the quantum well structure in the
8 expansion/contraction sections has a thickness which varies within said
9 expansion/contraction section and defines an expansion/contraction cutoff wavelength
10 which is shorter than the predetermined wavelength; and

11 an electroabsorption section extending between the two expansion/contraction
12 sections and including a portion of the quantum well structure having, responsive to
13 the on-voltage of the electric signal, a first electroabsorption cutoff wavelength which
14 is shorter than the predetermined wavelength; and, responsive to the off-voltage of the
15 electric signal, a second electroabsorption cutoff wavelength which is longer than the
16 predetermined wavelength;

17 a semiconductor layer coupled to the waveguide layer;

18 a first electrode coupled to the substrate; and

19 a second electrode coupled to the semiconductor layer wherein the electric signal is
20 applied between the first and second electrodes.

1 6. A method of manufacturing a monolithic expanded beam mode
2 electroabsorption modulator which includes a substrate with a top surface and substrate index
3 of refraction; a waveguide layer with a two expansion/contraction sections and an
4 electroabsorption section arranged along a longitudinal axis; and a semiconductor layer, the
5 method comprising the steps of:

6 a) forming at least one patterned growth retarding layer on the top surface of the
7 substrate

8 b) forming a waveguide layer having a waveguide index of refraction different
9 from the substrate index of refraction on a portion of the top surface of the substrate by
10 selective area growth, the waveguide layer including;

11 an electroabsorption portion having an electroabsorption thickness which is
12 greater than thicknesses in other portions of the waveguide layer; and

13 a plurality of sublayers forming a quantum well structure, each of the
14 sublayers including a waveguide material;

15 c) forming the semiconductor layer on the waveguide layer, the semiconductor
16 layer including a semiconductor layer index of refraction different from the waveguide index
17 of refraction;

18 d) defining and etching the waveguide layer and the semiconductor layer;

19 f) planarizing the semiconductor layer;

20 g) depositing a first electrical contact on the substrate; and

21 h) depositing a second electrical contact on the semiconductor layer.

1 7. The method of claim 6, wherein the step of forming the patterned growth
2 retarding layer includes forming a plurality of growth retarding elements, the growth
3 retarding elements defining a channel extending along a central portion of the longitudinal
4 axis, wherein the channel has a width greater than the electroabsorption width.

1 8. The method of claim 6, wherein step d) further includes the step of removing
2 the growth-retarding layer.

1 9. An optical signal modulation system comprising;

2 a laser which produces a light beam with a predetermined wavelength and a first
3 beam mode;

4 a monolithic expanded beam mode electroabsorption modulator including;

5 an input surface optically coupled to the laser and substantially optimized for low
6 input loss of light beams with the first beam mode;

7 an expansion section to expand a beam mode of the light beam for increased
8 confinement of the light beam;

9 an electroabsorption modulation section including a quantum well structure for
10 modulating light of the predetermined wavelength;

11 a contraction section to contract the beam mode of the light beam to a mode which
12 approximates the first beam mode; and

13 an output surface; and

14 an optical fiber optically coupled to the output surface of the monolithic expanded
15 beam mode electroabsorption modulator and substantially optimized for low input loss and
16 for transmission of light beams with the first beam mode.

1 10. An extended range optical communication system comprising;

2 a laser which produces a light beam with a predetermined wavelength and a first
3 beam mode;

4 a first optical fiber for transmission of light beams with the predetermined wavelength
5 and the first beam mode, including an input end optically coupled to the laser and an output
6 end;

7 a monolithic expanded beam mode optical amplifier including;

8 an input surface optically coupled to the output end of first optical fiber and
9 substantially optimized for relatively low input loss of light beams with the first beam
10 mode;

11 an expansion section to expand a beam mode of the light beam for increased
12 confinement of the light beam;

13 an optical amplification section including a semiconductor gain medium for
14 amplifying light of the predetermined wavelength;

15 a contraction section to contract the beam mode of the light beam to
16 approximate the first beam mode; and

17 an output surface; and

18 a second optical fiber optically coupled to the output surface of the monolithic
19 expanded beam mode optical amplifier and substantially optimized for low input loss and
20 transmission of light beams with the first beam mode.

1 11. An extended range optical communications system according to claim 10
2 wherein the semiconductor gain medium includes a bulk active material.

1 12. An extended range optical communications system according to claim 10
2 wherein the semiconductor gain medium includes a quantum well structure.

1 13. A low-loss demultiplexer in a temporally multiplexed optical communication
2 system for demultiplexing an input signal including a plurality of channels, each channel
3 modulated at a channel bit rate and temporally offset from other ones of the plurality of
4 channels by less than a minimum time between bits, comprising;

5 an input optical signal source;

6 a monolithic expanded beam mode electroabsorption modulator including;

7 an input surface optically coupled to the input optical signal source and
8 substantially optimized for low input loss of the input signal;

9 an expansion section to expand a beam mode of the input signal for increased
10 confinement of the input signal;

11 an electroabsorption modulation section including a quantum well structure for
12 modulating light of the expanded input signal to select one channel of the input signal
13 by periodic modulation at the channel bit rate and temporal offset of the selected
14 channel;

15 a contraction section to contract the beam mode of the selected channel of the
16 input; and

17 an output surface; and

18 a receiver optically coupled to the output surface of the monolithic expanded beam
19 mode electroabsorption modulator to receive the selected channel of the input signal.

1 14. A low-loss demultiplexer for demultiplexing a time division multiplexed
2 optical signal including a plurality of channels, each channel transmitted as blocks of pulses
3 which are temporally interleaved with blocks of pulses of other channels, comprising;

4 an optical beam splitter for splitting the time division multiplexed optical signal into a
5 plurality of split optical signals;

6 a monolithic expanded beam mode electroabsorption modulator including;

7 an input surface optically coupled to one of the split optical signals of the
8 optical beam splitter and substantially optimized for low input loss of the one split
9 optical signal;

10 an expansion section to expand a beam mode of the one split optical signal for
11 increased confinement of the one split optical signal;

12 an electroabsorption modulation section including a quantum well structure for
13 modulating light of the expanded one split optical signal to select blocks of a first
14 channel of the one split optical signal;

15 a contraction section to contract the beam mode of the selected first channel
16 blocks; and

17 an output surface; and

18 a buffer optically coupled to the output surface of the monolithic expanded beam
19 mode electroabsorption modulator to store the selected first channel blocks.

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